IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

IN RE APPLICATION OF   : Kazuo Nakajima et al.
APPLN. NUMBER   : 10/ 784,932
FOR   : MULTI-ELEMENTAL POLYCRYATAL FOR
SOLAR CELLS AND METHOD OF MANUFACTURING THE SAME
FILED   : February 2, 2004
GROUP ART UNIT   : 1753
EXAMINER   : Alan Diamond

DECLARATION UNDER 37 C.F.R. 1.132

Assistant Commissioner for patents
Washington, D.C. 20231

Sir:

I, Noritaka Usami, a national of Japan, declare as follows.

I graduated from the Department of Applied Physics, the University of Tokyo in 1991 and entered the graduate school for a master's degree in the Department of Applied Physics, the University of Tokyo in 1991. After finishing the graduate course in the Department of Applied Physics, the University of Tokyo in 1993, I was enrolled in a doctor course in the Department of Applied Physics, the University of Tokyo in 1993, and obtained my doctor's degree in Engineering in 1998.

I was a researcher at the Japan Society for the Promotion of Science in 1993, and then a research associate at the Research Center for Advanced Science and Technology, the University of Tokyo.

From 1998 to 1999, I was a visiting researcher at the Institut fuer

Angewandte Photophysik, Technische Universitaet Dreseden.

I have been an associate professor at Institute for Materials Research (IMR), Tohoku University since 2000.

I am a co-applicant of the above-identified application.

In order to verify the fact that the SiGe crystal according to the present invention, in which the ratio of Ge is set to 10 at% or less, or particularly, 5 at% or less, exhibits excellent properties that cannot be expected from US2002/0139416: Nakajima et al., I conducted the following experiment.

Experiment 1:

Si and Ge were mixed at the equal atomic % (50 : 50), and the mixed material was melted.   The molten fluid was solidified and grown while controlling the cooling rate to form a $Si_{0.5}Ge_{0.5}$ crystal of the present invention (each crystal grain of which has a metal structure in which a plurality of segregation regions are dispersedly distributed within a matrix).   Using the obtained $Si_{0.5}Ge_{0.5}$ crystal, a solar cell was manufactured and the current-voltage characteristics of the cell under illumination were measured. The results are shown in FIG. 1 attached thereto.   From the attached FIG. 1, it can be under stood that the open circuit voltage of the solar cell that uses the $Si_{0.5}Ge_{0.5}$ crystal of the present invention was 0.41V.   In comparison, the open circuit voltage of the solar cell that uses Si polycrystal was about 0.55 to 0.58V.   Thus, the open circuit voltage significantly lowers.

On the other hand, the open circuit voltage of the SiGe polycrystal of the present invention in which the Ge amount is set more than 0 atomic % but

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no more than 10 atomic %, is set out in FIG. 4 (B) in the specification of the

present application.   As can be understood from FIG. 4 (B), the open circuit

voltage of the SiGe polycrystal of the present invention in which the Ge amount

is set more than 0 atomic % but no more than 10 atomic % is about 0.43 to

0.58V.   The open circuit voltage of the SiGe polycrystal of the present

invention in which the Ge amount is set more than 0 atomic % but no more than

5 atomic % is about 0.55 to 0.58V.   Thus, the lowering of the open circuit

voltage was not monitored as compared to the Si polycrystal solar cell.

Experiment 2:

Based on a $Si_{0.97}Ge_{0.03}$ crystal of the present invention, in which a

plurality of segregation regions are dispersedly distributed within a matrix, as a

model, $Si_{0.97}Ge_{0.03}$ crystals were obtained for the following cases where

SiGe thin films of different compositions are laminated while setting the average

composition constantly to 3% and the value of {(maximum Ge composition) -

(minimum Ge composition) %} was adjusted to 1%, 4% and 6%.

As a control, an $Si_{0.97}Ge_{0.03}$ crystal having a microscopically

uniform composition (that is, (maximum Ge composition) - (minimum Ge

composition) % was 0%) was manufactured by a thin film growing method.

With these SiGe crystals, solar cells were manufactured, and they

were measured in terms of the short circuit photocurrent, open circuit voltage

and conversion efficiency.   In each of FIGS. 2 (A), (B) and (C) attached hereto,

the numerical value of {(maximum Ge composition) - (minimum Ge

composition)} (%) within the crystal is taken in the horizontal axis.   When the

numerical value is 0, it means an $Si_{0.97}Ge_{0.03}$ crystal having a

microscopically uniform composition.

In each of FIGS. 2 (A), (B) and (C), the vertical axis indicates the

relative value of the short circuit photocurrent, open circuit voltage and

conversion efficiency, respectively.

Each relative value is a value with relative to the measured value of the

case of the $Si_{0.97}Ge_{0.03}$ crystal having a microscopically uniform

composition being set to 1.00.

As can be understood from FIG. 2 (A), the short circuit photocurrent of

the SiGe crystal of the present invention is no less than about 1.06 times higher

than the control, as can be understood from FIG. 2 (B), the open circuit voltage

is no less than about 1.08 times higher, and as can be understood from FIG. 2

(C), the conversion efficiency is no less than about 1.05 times higher.

I, the undersigned, declare further that all statements made herein of

my own knowledge are true and that all statements made on information and

belief are believed to be true; and further that these statements were made with

the knowledge that willful false statements and the like so made are punishable

by fine or imprisonment, or both, under Section 1001 of Title 18 of the United

States Code and that such willful false statements may jeopardize the validity of

the this application or any patent issuing thereon. ·
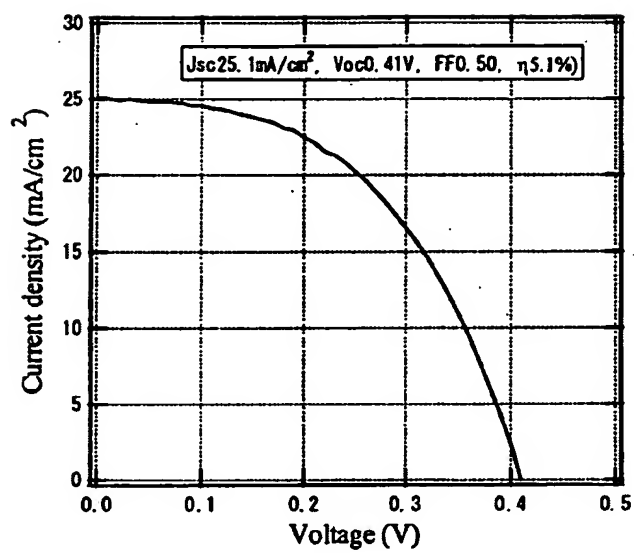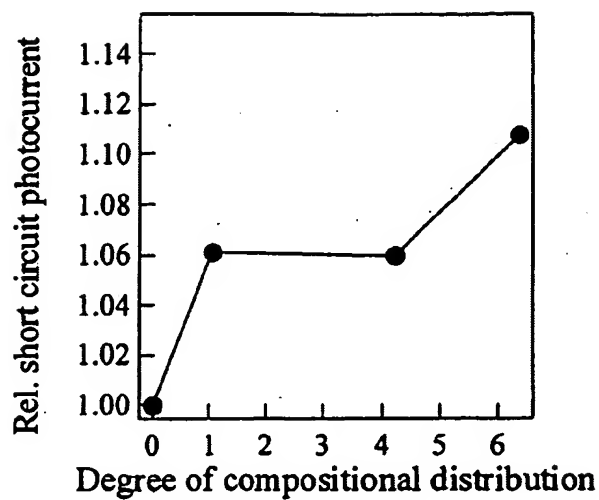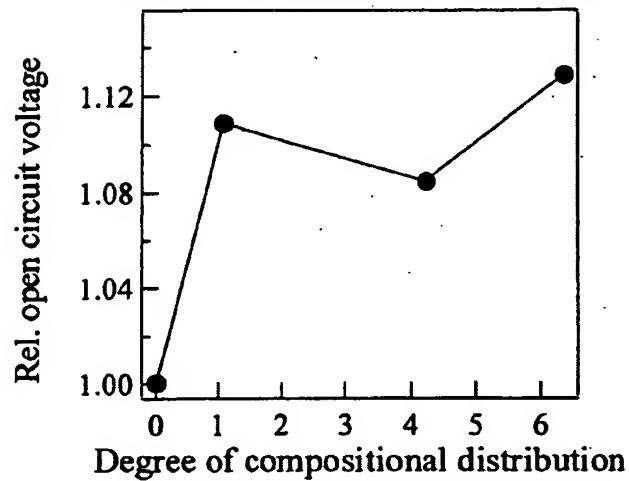
Date   May 19, 2006

Noritaka Usami

Fig. 1

Jsc25. 1mA/cm², Voc0. 41V, FF0. 50, η5.1%)

Fig. 2

(A)

Rel. short circuit photocurrent vs Degree of compositional distribution

(B)

Rel. open circuit voltage vs Degree of compositional distribution

(C)

Rel. conversion efficiency vs Degree of compositional distribution